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Ontario

Ministry
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Environment

The Honourable
Harry C. Parrott, D.D.S.,
Minister

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Deputy Minister

1 9 7 8 H A M I L T O N

A I R Q U A L I T Y

TECHNICAL SUPPORT SECTION

WEST CENTRAL REGION

JUNE, 1979

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SUMMARY

Air quality in Hamilton has improved significantly since 1970 for most of the monitored pollutants. The main concern now is particulate matter, a pollutant arising from both man-made and natural sources. Total suspended particulate (TSP) levels dropped most perceptively during the 1972-75 period as shown in Figure 1 and this improvement is attributable to the control programs instituted by the major industries in conjunction with the Ministry of the Environment. Since 1975, TSP levels have remained relatively stable and are still unsatisfactory in many areas of the city, especially near the heavy industry. Soiling index shows a similar trend to TSP, however, dustfall levels have shown no improvement during the 1970's - they have remained constant and well above our objectives in a large part of the City.

Levels of sulphur dioxide, carbon monoxide and oxides of nitrogen, all products of industrial or automotive fuel combustion, remained acceptable in 1978 and generally met objectives with some rare exceptions for sulphur dioxide and nitrogen dioxide.

Reactive hydrocarbons (non-methane), also products of automotive and industrial fuel consumption, have remained constant over three years of measurement and although there are no objectives for them, the levels are higher than in most other communities.

Levels of total reduced sulphur (formerly identified as hydrogen sulphide) which are mainly industrially source oriented, continued to show some high readings in 1978. The objective was exceeded several times, mostly at the Barton/Sanford location. These high concentrations usually occurred during inversion conditions which were characterized by elevated air pollution index readings.

Ozone levels have remained relatively constant over the 1975-78 period. Ozone, a secondary pollutant arising from photochemical reactions in the atmosphere, is a continent if not world scale problem and undesirable health effects have been documented for high dosage exposures. Elevated levels above the objective have been recorded throughout Southern Ontario and the United States. Ozone can be transported over long distances away from the sources of its precursors and be augmented by locally produced ozone. Most of Southern Ontario's high levels seem to be caused by long range transport from the United States. In Hamilton, concentrations are generally lower than in other localities, probably due to the numerous high temperature combustion sources in the city which produce higher levels of nitric oxide, a scavenger of ozone.

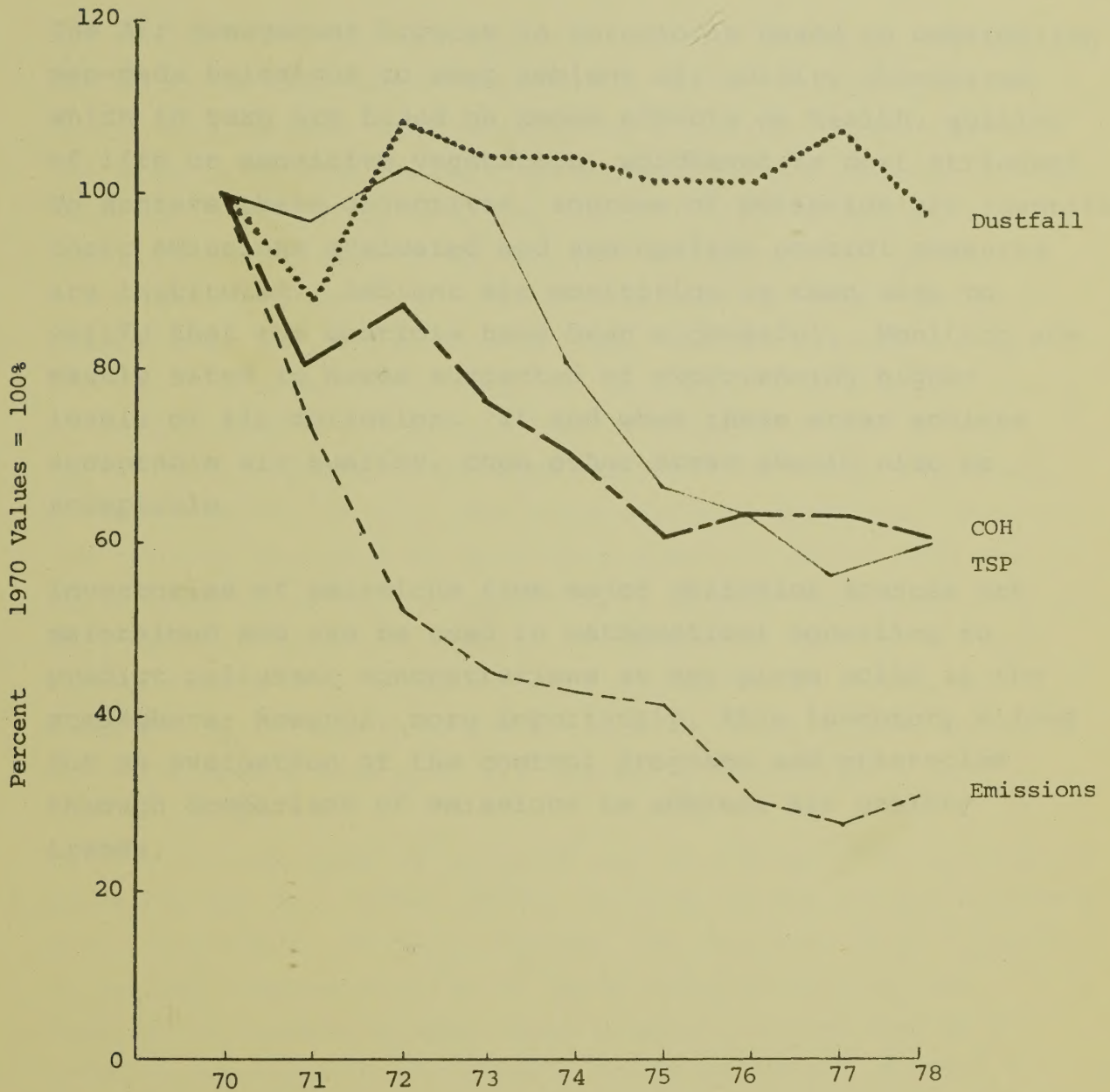
Sulphur and fluoride emissions stem mostly from industrial sources as indicated by sulphation and fluoridation rates, both of which continued to show elevated levels near the industrial area in 1978. The levels were much lower 1 - 2 kilometers from this area, however, while sulphation rates became generally much lower at such distances, the fluoridation rate objectives were still often marginally exceeded at several more distant locations. However, based on past phytotoxicology studies, it is improbable that the fluoride levels were high enough to cause vegetation damage.

The Air Pollution Index (API) exceeded 32 on seven occasions during 1978, mostly during the spring. These incidents were usually a result of the classical lake breeze effect which creates an inversion over the city. The most significant incident lasted 25 hours on November 3 - 4.

FIGURE 1

Particulate Trends vs Estimated Total Emissions

Hamilton 1970 - 1978



TSP (7 stations)	131	127	135	130	104	86	83	73	77	ug/m ³
Dustfall (19 stns)	9.1	8.0	9.8	9.5	9.5	9.3	9.3	9.7	8.9	g/sq.m/30 days
COH (7 stations)	.54	.43	.47	.41	.38	.33	.34	.34	.33	COH's/1000 ft.
Institutional & Industrial Emissions	56	41	29	25	24	23	17	16	17.5	10 ⁶ lbs/year

Introduction

The Air Management Program in Ontario is based on controlling man-made emissions to meet ambient air quality objectives, which in turn are based on known effects on health, quality of life or sensitive vegetation, whichever is most stringent. To achieve these objectives, sources of pollution are identified, their emissions evaluated and appropriate control measures are instituted. Ambient air monitoring is then used to verify that the controls have been successful. Monitors are mainly sited in areas suspected of experiencing higher levels of air pollution. If and when these areas achieve acceptable air quality, then other areas should also be acceptable.

Inventories of emissions from major pollution sources are maintained and can be used in mathematical modelling to predict pollutant concentrations at any given point in the atmosphere; however, more importantly, this inventory allows for an evaluation of the control programs and strategies through comparison of emissions to ambient air quality trends.

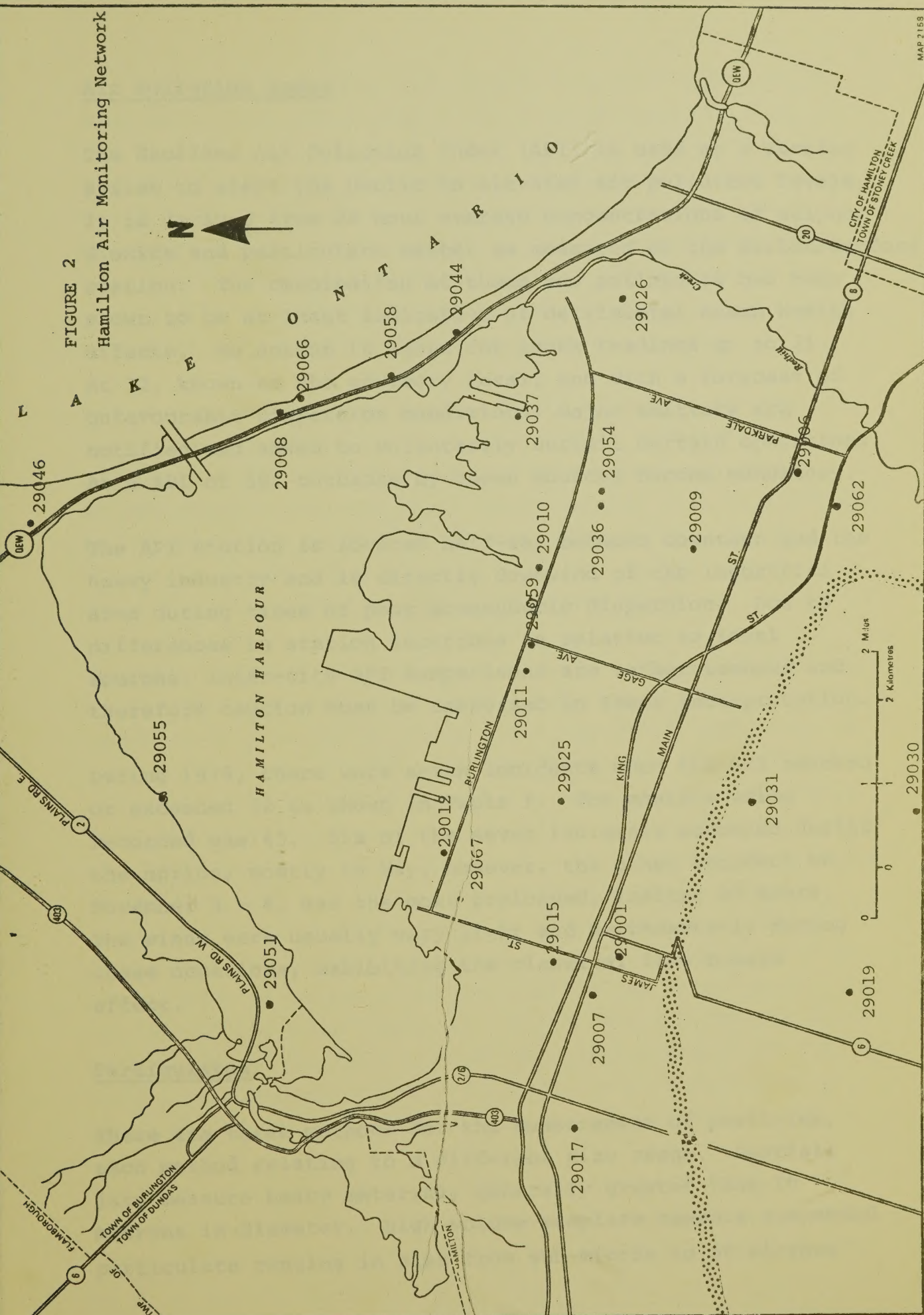
Monitoring Network

The Ministry of the Environment operates a network of ambient air monitors throughout Hamilton as shown in Figure 2.

Monitoring is most concentrated in the lower City, that is the area below the Niagara Escarpment and the network is centred on two major stations which monitor a variety of pollutants with mostly automated analyzers. The main station, known as 29025 - Barton/Sanford provides the data which forms the basis for the Hamilton Air Pollution Index (API). The other major station is on the Beach Strip and is known as 29008 - North Park, immediately adjacent to the Queen Elizabeth Way. The remainder of the network consists of numerous but mostly less sophisticated monitors. Most of the network has been in existence since at least 1970 and is considered to serve this Ministry's requirements adequately. Besides this regular network, occasionally special surveys are carried out in order to identify specific problems; however, these data are not included in this report which is an evaluation of general air quality in Hamilton.

Meteorological data (wind speed and direction and temperature) are observed at station 29026, located on the sewage treatment plant grounds on Woodward Avenue. We consider this location to be more representative of local conditions than the Federal Government's Mount Hope Weather Station due to the complex meteorological patterns which sometimes prevail in Hamilton. This feature will be addressed later on in this report.

FIGURE 2
Hamilton Air Monitoring Network



Air Pollution Index

The Hamilton Air Pollution Index (API) is used as a warning system to alert the public to elevated air pollutant levels. It is derived from 24 hour average concentrations of sulphur dioxide and particulate matter as measured at the Barton/Sanford station. The combination of these two pollutants has been shown to be at least indicative of detrimental human health effects. No action is taken for index readings up to 31. At 32, known as the advisory level, and with a forecast of unfavourable dispersion conditions, major emitters are notified and asked to voluntarily curtail certain operations. At a API of 50, cutbacks by these sources become mandatory.

The API station is located half-way between downtown and the heavy industry and is directly downwind of the industrial area during times of poor atmospheric dispersion. Due to differences in station locations in relation to local sources, inter-city API comparisons are rather tenuous and therefore caution must be exercised in their interpretation.

During 1978, there were seven incidents when the API reached or exceeded 32 as shown in Table 1. The maximum value recorded was 43. Six of the seven incidents occurred during the spring, mostly in May, however, the other incident on November 3 - 4, was the most prolonged, lasting 25 hours. The winds were usually very light and northeasterly during these occasions, exhibiting the classical lake breeze effect.

Particulates

There are three methods for the measurement of particles, each method relating to a different size range. Dustfall jars measure heavy material, generally greater than 10 microns in diameter. High volume samplers measure suspended particulate ranging in size from sub-micron to 50 microns

and coefficient of haze tape samplers measure mostly fine material - from sub-micron to about 10 microns.

The ambient air quality objectives for suspended particulate and soiling are based on health effects when occurring in combination with sulphur dioxide. As mentioned previously, this combination was proven only to be indicative but not necessarily causative of such health effects. The dustfall objectives are based on nuisance effects.

The high volume sampler draws a known volume of air through a pre-weighed filter for a 24 hour period (midnight to midnight). The exposed filter is weighed and the difference in conjunction with the known amount of air flow is expressed as concentration in micrograms per cubic meter. At two locations in Hamilton, these devices run daily. At all other locations they run on a once every sixth day cycle.

Suspended particulates at the nine hi-vol locations generally showed little change in 1978 from previous years. Lowest levels were measured downtown where the yearly objective was only marginally exceeded. In the industrial area, conditions were poor. At the Burlington/Leeds location, the geometric mean increased considerably from 95 to 133 $\mu\text{g}/\text{m}^3$, the highest the level has been since 1975. This increase can be attributed to construction and demolition activities which occurred throughout 1978 in close vicinity of the monitor. The apparent deterioration is probably not representative of the entire area as indicated by the lack of any significant changes at the other stations. The Barton/Sanford and North Park stations also continued to show high means - 102 and 93 $\mu\text{g}/\text{m}^3$, respectively, similar to 1977. Both locations had about 35% of their samples in excess of our daily objective.

Coefficient of haze tape samplers operate continuously and determine hourly or two-hour average soiling values. Air is drawn through a filter paper and the optical density of the

soiled spot is measured by light transmittance. Unfortunately, the 1-hour telemetered instruments have been demonstrated to yield values at least 25% higher than the 2-hour instrument for equal samples of air and hence, the two types of measurement are not directly comparable. Although the air quality objectives were initially formulated on the basis of 2-hour measurements, it is not known which instrument better reflects actual conditions. For these reasons, the two types of data are presented and discussed separately.

A common observation of both methods is that levels have remained stable since 1975. The main station on Barton Street and the North Park Station both employ 1-hour instruments. The yearly means in 1978 were both above the objective and the daily objective was exceeded frequently; 82 times at North Park and 26 times at Barton. The data is summarized in Table 3. The high levels usually occurred when the monitors were downwind of the industrial area which indicates that the heavy industry is a source of fine particulate matter.

The six other locations employ 2-hour instruments (Table 4) and all recorded low and acceptable levels in 1978. Somewhat surprisingly the station closest to the industrial area at Kenilworth and Roxborough Avenues recorded the lowest levels. The downtown readings were marginally higher.

Dustfall is that material which settles out of the atmosphere by gravity and is collected in elevated plastic containers during a 30 day exposure time. The collected material is weighed and expressed as a deposition rate of grams/sq. meter/ 30 days. The significance of observations is restricted to very local areas.

Dustfall levels in 1978 (Table 5) remained similar to those of previous years. Figure 3 depicts dustfall isopleths and shows that a large part of the lower city and the Beach

Strip was encompassed by the 9.0 grams/sq. meter contour which represents twice our objective. Conditions in this area, for the most part, were quite poor. The significance of re-entrainment to dustfall loadings is shown by the lower loadings in January and February, when there is snow cover on the ground. The January/February average for all stations combined was 5.4 grams compared to an overall year long average of 8.4 grams. The only real exception to this phenomenon was North Park where January and February values were higher than during most of the rest of the year. It is probable that heavy salting of the QEW and the resulting re-entrainment from this highway could have caused this observation.

Sulphur Dioxide

Most sulphur dioxide (SO_2) emissions in Hamilton, as detailed by the emissions inventory stem from industrial sources. Only a small portion is accounted for by fuel burning in domestic space heating.

The Barton/Sanford and North Park stations monitor SO_2 continuously and data is summarized in Table 6. The levels at both locations have been generally acceptable in recent years, although the yearly averages had been gradually increasing from 1972 to 1977. In 1978, the yearly means improved and resulted in values below our objective. The hourly objective was exceeded once at Barton Street - the first such occurrence there since 1970, but the 24-hour objective was met at both locations throughout the year. These SO_2 objectives are based on vegetation damage.

Total Reduced Sulphur

This pollutant was formerly identified as hydrogen sulphide (H_2S). However, since the analyzer also reacts to other sulphur compounds, the data is now reported as total reduced sulphur. The objective for hydrogen sulphide is still applied to the observed values and is based on the odour

threshold level. Both Barton/Sanford and North Park monitor continuously and data are summarized in Table 7.

The major industrial sources of hydrogen sulphide and related sulphur compounds are the steel industries' coke ovens and a local manufacturer of carbon black. Another potential but rather minor source is Windermere Basin. Sulphur bearing organic sediments from Red Hill Creek and sewage overflow from the sewage treatment plant may, under certain adverse conditions during the spring, decompose and produce hydrogen sulphide. The sewage treatment plant itself is another minor source, but only during certain upset conditions when similar undesirable decompositions of sewage can occur.

In 1978, the yearly averages increased at both stations. However, the number of values that exceeded the hourly objective remained about the same as in 1977; 74 at Barton and 5 at North Park. The high concentrations at Barton usually occurred during inversion conditions which were characterized by elevated API values. At North Park, there were not as many high values since southwest winds, even though predominant, normally offer good dispersion of emissions.

Carbon Monoxide

The major source of carbon monoxide emissions generally is the automobile, however, in Hamilton there are also some contributions from industry. Due mainly to automotive emission controls, the levels measured at Barton Street decreased greatly over the 1970-75 period. Since 1975, the levels have remained relatively stable, well below objectives. In 1978, a further small reduction was observed. The objectives for this pollutant are based on health effects.

Oxides of Nitrogen

The primary source of oxides of nitrogen are high temperature combustion sources. The most abundant oxides are nitric oxide (NO) and nitrogen dioxide (NO₂) and they are monitored continuously at both Barton/Sanford and North Park. At each station a single instrument makes measurements of NO, NO₂, and total nitrogen oxides. Nitric oxide is measured directly and total oxides are measured by internally converting all other nitrogen oxides to nitric oxide. The instrument then determines nitrogen dioxide to be the difference between the first two measurements.

Of the three reported pollutants, objectives exist only for nitrogen dioxide and these are based on the odour threshold and health effects.

The levels of NO₂ (Table 9) have remained stable since the present method of measurement was employed in 1977, with objectives rarely exceeded. In 1978, the 24-hour objective was exceeded once at North Park and three times at Barton. The 1-hour objective was not exceeded at either station. Both nitric oxide and total nitrogen oxides (Tables 10 and 11 respectively) have also shown similar stable levels over the years. An interesting observation to note is that while nitrogen dioxide levels have remained similar at both stations each year, nitric oxide levels have generally been three times as high at North Park then at Barton. This can probably be explained by North Park's close proximity to heavy traffic on the Queen Elizabeth Way and prevailing southwest winds. Most of the oxides of nitrogen emitted from automobile tailpipes are present as nitric oxide which is then oxidized to nitrogen dioxide in the atmosphere. The station probably monitors the automobile emissions before this conversion can fully take place.

Oxides of nitrogen are an important factor in the photochemical production of ozone which will be discussed later in this report.

Hydrocarbons

In Hamilton, hydrocarbon emissions are associated with industrial sources as well as with automobiles. There is a considerable quantity of hydrocarbons being produced by natural sources, such as methane due to decomposition of grasses, plants and trees. Our concern, however, is mainly with the man-made portion of this pollutant which can react with other substances under appropriate climatic conditions to result in secondary pollutants. This man-made portion comprises a considerable and variable number of substances and is referred to as non-methane or reactive hydrocarbons. Only the non-methane portion of the pollutants have been monitored at Barton Street since 1976. During the three years of measurement, the levels have remained stable, but relatively high compared to other communities. Data are summarized in Table 12. No objectives exist for these pollutants, however, the monitoring is important for trend purposes and strategy planning as well as for hydrocarbons' importance in the photochemical production of ozone.

Ozone

Oxidants are mainly a product of photochemical reactions involving oxides of nitrogen, hydrocarbons and sunlight. Ozone accounts for most of the oxidants produced. The sources of the precursor pollutants are mainly industrial and automotive. The automobile is a major source of both nitrogen oxides and hydrocarbons and is known to be the prime cause of the Los Angeles photo chemical smog problem. In the eastern United States and Canada, emissions from heavy industry compound the automotive problem.

Ozone is also naturally present in the stratosphere and acts as a shield protecting the earth's surface from harmful ultra-violet radiation. Occasionally some of this ozone may be transported downward to the lower atmosphere; however, this is probably a very minor source.

Ozone is known to be associated with many respiratory problems and at elevated concentrations people can experience adverse health effects. Ozone is also injurious to different types of vegetation including certain tobacco crops. The 1-hour objective for ozone is based on both health and vegetation effects.

Ozone concentrations follow very definite annual and daily trends. Highest levels occur during the summer (May - September) and the daily maximums usually occur during mid-afternoon. Both patterns are directly related to the amount and intensity of sunlight.

This pollutant has been monitored at the Barton Street station since 1975. During 1978, as in each of the previous years, there were several hourly observations above the 80 ppb objective as shown in Table 13, mostly occurring during the critical May - September period. These elevated concentrations were common throughout southern Ontario and were largely a result of long range transport from the heavy urbanized area of the United States.

Ozone, hydrocarbons and oxides of nitrogen can be transported over great distances and be augmented by local sources. However, Hamilton and other major urban areas usually experience lower ozone concentrations than their more rural surroundings during these peak occurrences. In fact, the concentrations in Hamilton are among the lowest recorded in Southern Ontario, probably due to the numerous high temperature combustion sources which produce higher levels of nitric oxide, a scavenger of ozone. Nevertheless, ozone and other oxidants remain a problem which due to the complexity of their formation and the long range transport phenomenon, will have to be resolved on an international rather than local scale.

Sulphation

Sulphation rate is a crude measurement used to determine relative quantities of various sulphur compounds in the ambient air. A paper coated with lead peroxide is exposed to the atmosphere for approximately 30 days and then chemically analyzed for sulphur. The results are reported as depositions of sulphur trioxide. Initially, the sulphation objective was based on the sulphur dioxide yearly goal. However, the correlation between sulphation rate and sulphur dioxide depends on the type and number of different compounds involved, and because of this variability, the sulphation objective has been dropped in 1979.

Although the measurement is crude it is useful for trend determination purposes as well as detecting severe pollution problems which call for more sophisticated instrumentation.

The 1978 levels showed little change from previous years as shown in Table 14. Near the industrial area, the former objective was exceeded often at several locations, however, levels dropped rapidly with distance and were generally much lower from 1 - 2 kilometers from the heavy industry. Due to unresolved laboratory interpretation problems, 1977 data were considered invalid and are not presented.

Fluoridation

This measurement is a crude assessment similar to that for sulphation. A lime coated paper is exposed to the atmosphere for approximately 30 days and is then chemically analysed for fluoride. The fluoride objectives are based on vegetation damage and for this reason the objective is more stringent during the growing season. For the period April 15 to October 15, it is 40 mg/100 sq. cm/30 days while for the remainder of the year it is 80.

In Hamilton, the major fluoride sources are the basic oxygen furnaces used by the major steel industries which require fluorspar, a fluxing agent. In addition to these process emissions, there are other more minor sources such as coal burning since coal contains trace amounts of fluoride.

The 1978, fluoride results, presented in Table 15, showed a significant increase in concentrations in 1978, on the average by about 25%. This may partly be attributed to an increased use of fluorspar by the steel industry. The concentrations were unacceptably high near the heavy industry on Burlington/ Gage and on the Beach Strip where highest levels were once again found at station 29058. Concentrations decreased with distance from the industrial area, however, the objectives were still exceeded occasionally at several other locations.

Annual phytotoxicology studies during 1970-76 revealed that the ratio of fluoride concentrations in not-washed to washed vegetation averaged 2:1. This indicates that much of the fluoride contamination on vegetation was associated with airborne particulates, easily removed by washing. However, both washed and not-washed results were considered excessive in many locations in 1976. Despite these excessive levels, no fluoride injury symptoms had been observed since 1972. This fact can probably be attributed to the discontinued use of fluorspar in the open hearth furnaces at the Steel Company of Canada in 1973.

Since the Phytotoxicology results correlate closely with the lime candle fluoridation results (for the 1972 - 76 period), it is reasonable to assume that no fluoride injury symptoms would have been found on native Hamilton vegetation in 1978, because the average fluoridation levels were still well below those of 1973 when no symptoms were observed.

Discussion

Air quality in Hamilton remains of great concern to the Ministry of the Environment. Despite significant improvements in pollutant levels from the early 1970's, levels of some pollutants, especially particulate matter remain unacceptable in many parts of the City and have generally shown little improvement since 1975 even though inventoried emissions have further decreased. This indicates that apart from further reductions in industrial process emissions, other less obvious sources of dust such as unpaved areas, material stock piles, demolition and construction activities and traffic may have to be controlled as well. Any re-direction, however, must first be proven to be a potentially worthwhile effort and studies are now underway to determine the effect of some of these mostly uncontrolled sources.

To date, efforts to determine the exact extent of industry's contribution to pollutant levels have proven difficult. One of the major difficulties in this assessment is the City's unique geographical setting which creates complex meteorological conditions. The heavy industries' location beside Lake Ontario combined with the Niagara Escarpment often make simple wind direction studies not viable. While the effects of lake based inversions are well documented with their sometimes discomforting effects, less is known of inversions aloft, stagnation conditions, return flow of dispersed pollutants and other such meteorological conditions which radically affect ambient air quality in the city.

TABLE IAIR POLLUTION INDEXOccasions when A.P.I. was 32 or above

1978

Number	Date	Maximum Index	Number of Hours ≥ 32
1	Mar. 10-11	34	7
2	May 8	32	3
3	May 12	33	8
4	May 23-24	36	20
5	May 27-28	35	17
6	May 30-31	34	13
7	Nov. 3-4	43	25
			<u>93</u>

1977

1	Jan. 14-15	35	8
2	Feb. 24	32	4
3	Mar. 11-13	44	48
4	Mar. 28-29	34	21
5	Apr. 19-21	39	46
6	May 5	32	5
7	May 21-22	34	16
8	Oct. 25-26	42	30
9	Nov. 3-4	34	23
			<u>201</u>

1976

1	Mar. 27	34	12
2	Mar. 30	35	11
3	May 29 - June 1	37	60
4	July 22-23	32	2
5	Sept 9	34	10
6	Sept 17	33	6
7	Dec. 16-17	40	21
			<u>122</u>

TABLE 2

SUSPENDED PARTICULATES - 1978

UNITS - MICROGRAMS PER CUBIC METER

ONTARIO OBJECTIVES: 24-Hour-120
1-Year Geo. Mean - 60

	No. of Samples	Geometric Mean 1978 1977 1976	Maximum	No. of Times Above 120
29001 - Hughson/Hunter	58	64 63 76	346	8
29007 - City Hall	57	61 54 65	169	7
29008 - North Park	318	93 94 102	521	114
29009 - Kenilworth	59	70 61 69	187	7
29011 - Burlington/Leeds	57	133 95 112	303	34
29012 - Burlington/ Wellington	57	74 70 76	241	11
29017 - Chatham/Frid	57	77 72 91	220	13
29025 - Barton/Sanford	304	102 96 99	503	109
29067 - Hughson St. N.	56	63 59 60	187	3

TABLE 3

SOILING INDEX - 1978

1-HOUR TELEMETERED INSTRUMENTS

UNITS - COH's per 1000 ft. of linear air

Ont. Objectives - 24 hour - 1.0
1 year - 0.5

	Annual Average		Maximum 1-hr. 24-hr.	No. of times above objective 24-hr.
	1978	1977 1976		
29008-North Park	.67	.63 .55*	3.3 1.6	82
29025-Barton/Sanford	.56	.54 .53	3.7 2.2	26

* July - December, 1976

1-hour telemetered data not directly comparable to 2-hour data - see text

TABLE 4

SOILING INDEX - 19782-HOUR INSTRUMENTSUNITS - COH's per 1000 ft. of linear air

	Annual Average		Ont. Objectives - 24 hour - 1.0 1 year - 0.5		No. of times above objective 24-hr.
	1978	1977	1976	Maximum 1-hr. 24-hr.	
29001 - Hughson/Hunter	.25	.28	.28	2.0 1.0	0
29009 - Kenilworth	.15	.20	.25	1.5 0.5	0
29012 - Burlington/ Wellington	.16	.26	.24	0.9 0.4	0
29015 - Merrick/James	.28	.26	.31	2.8 1.2	1
29017 - Chatham/Frid	.25	.20	.30	4.4 1.1	1
29067 - Hughson N.	.23	.22	.25	1.9 0.9	0

2-hour data not directly comparable to 1-hour telemetry data - see text

DUSTFALL 1978

UNITS - GRAMS/SQ. METRE/30 DAYS

Ontario Objectives: 1 Month Avg. 7.0
1 Year Avg. 4.5

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1978	AVERAGE 1977	1976
29001 Hughson/Hunter	4.8	4.6	9.3	10.3	11.8	6.6	5.0	5.3	6.4	4.2	4.0	6.7	6.5	8.2	8.4 ¹¹
29006 Queenston	3.7	5.3	10.8	18.2	11.1	7.9	8.6	5.1	8.3	5.5	5.5	6.5	8.0	9.1 ¹⁰	9.0
29008 North Park	21.4	11.7	6.2	9.6	11.0	9.4	10.4	-	12.5	14.7	9.4	22.1	12.6 ¹¹	17.7	13.1
29009 Kenilworth	4.4	4.5	9.2	8.2	9.2	6.3	3.7	5.1	8.2	5.0	5.4	4.1	6.1	6.4	5.9 ¹¹
29010 Burlington/Ottawa	7.1	9.7	24.0	15.4	23.6	11.0	10.2	16.2	12.7	-	-	-	14.4 ⁹	14.6	13.5
29011 Burlington/Leeds	7.5	8.7	20.4	29.5	22.2	-	6.2	11.4	19.1	10.4	14.5	14.3	14.9 ¹¹	14.6	14.8 ¹¹
29012 Burlington/Wellington	5.6	4.6	13.0	13.2	14.2	10.8	6.3	6.8	24.4	6.1	10.2	9.9	10.4	11.1	8.4 ¹¹
29017 Chatham/Frid	4.2	4.9	12.6	11.8	14.8	8.0	6.4	8.0	9.8	27.9	6.1	13.0	10.6	10.3	10.7
29019 Mohawk/Warren	2.5	1.8	4.8	4.5	-	5.8	5.3	4.0	6.7	4.5	3.1	3.3	4.2 ¹¹	6.1	5.6
29025 Barton/Sanford	5.9	4.4	11.6	12.6	17.3	13.0	6.6	9.6	12.7	5.2	8.2	6.8	9.5	11.5	10.1
29026 Woodward/Brampton	3.3	2.8	6.2	8.6	5.7	6.3	5.2	4.1	6.0	4.2	3.1	4.8	5.0	5.0	6.1
29030 Camden/Mohawk	4.3	2.7	7.4	6.0	8.8	10.6	7.8	8.2	6.4	4.9	4.1	4.3	6.3	6.5	7.1
29031 Concession/Upper Sherman	6.7	5.1	10.8	10.6	9.8	7.8	4.5	6.2	10.0	5.6	6.5	6.9	7.5	7.2	7.4

Underlined values are in excess of objective

DUSTFALL 1978

UNITS - GRAMS/SQ. METRE/30 DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1978	AVERAGE 1977	1976
29036 Roosevelt/Beach Rd.	5.3	<u>7.6</u>	<u>14.1</u>	<u>11.9</u>	<u>16.0</u>	<u>13.0</u>	<u>10.9</u>	<u>9.5</u>	<u>11.4</u>	<u>9.6</u>	<u>7.5</u>	<u>9.8</u>	<u>10.6</u>	<u>11.3</u>	<u>12.1</u>
29037 Strathearn	<u>10.6</u>	<u>8.8</u>	<u>18.1</u>	<u>16.4</u>	<u>18.3</u>	<u>12.6</u>	<u>12.3</u>	<u>18.9</u>	<u>17.8</u>	<u>20.2</u>	<u>16.2</u>	<u>23.2</u>	<u>16.1</u>	<u>17.3¹¹</u>	<u>18.0</u>
29044 Wark/Beach Blvd.	<u>11.1</u>	<u>8.6</u>	<u>14.8</u>	<u>11.5</u>	<u>13.5</u>	<u>12.0</u>	<u>12.1</u>	<u>11.6</u>	<u>11.8</u>	<u>8.2</u>	<u>9.6</u>	<u>14.5</u>	<u>11.6</u>	<u>11.9</u>	<u>12.9</u>
29046 Highways Bldg. Burlington	3.5	1.9	3.6	4.4	<u>9.7</u>	<u>12.8</u>	<u>12.6</u>	5.2	<u>8.0</u>	3.4	2.3	2.8	<u>6.7</u>	<u>7.2</u>	4.5
29050 Hopkins Crescent, Dundas	2.0	1.6	2.0	3.3	-	4.0	6.8	2.5	<u>7.7</u>	4.0	-	-	<u>3.8⁹</u>	<u>7.3</u>	4.1
29051 Botanical Gardens, Burlington	3.9	6.9	<u>9.5</u>	<u>11.7</u>	<u>9.2</u>	5.9	3.8	2.8	4.1	2.8	2.4	3.0	<u>5.5</u>	<u>6.2</u>	<u>5.7</u>
29055 La Salle Park, Burlington	1.4	1.0	2.0	3.5	3.1	5.2	3.4	2.2	4.3	1.7	1.6	2.6	2.7	<u>3.0¹¹</u>	2.9
29060 Stoney Creek Munic. Office	3.3	2.0	<u>10.4</u>	<u>8.4</u>	6.0	7.0	3.0	4.2	<u>8.4</u>	4.7	4.7	<u>7.2</u>	<u>5.8</u>	<u>5.4</u>	<u>6.5</u>
29067 Hughson Street North	3.2	2.7	<u>7.3</u>	<u>8.0</u>	<u>7.5</u>	<u>8.8</u>	5.0	6.2	<u>7.5</u>	1.5	5.9	6.2	<u>5.8</u>	<u>7.6¹¹</u>	<u>8.3</u>

Underlined values are in excess of objective

FIGURE 3
Isopleths of 1978 Dustfall
Averages
Grams/sq. meter/30 days

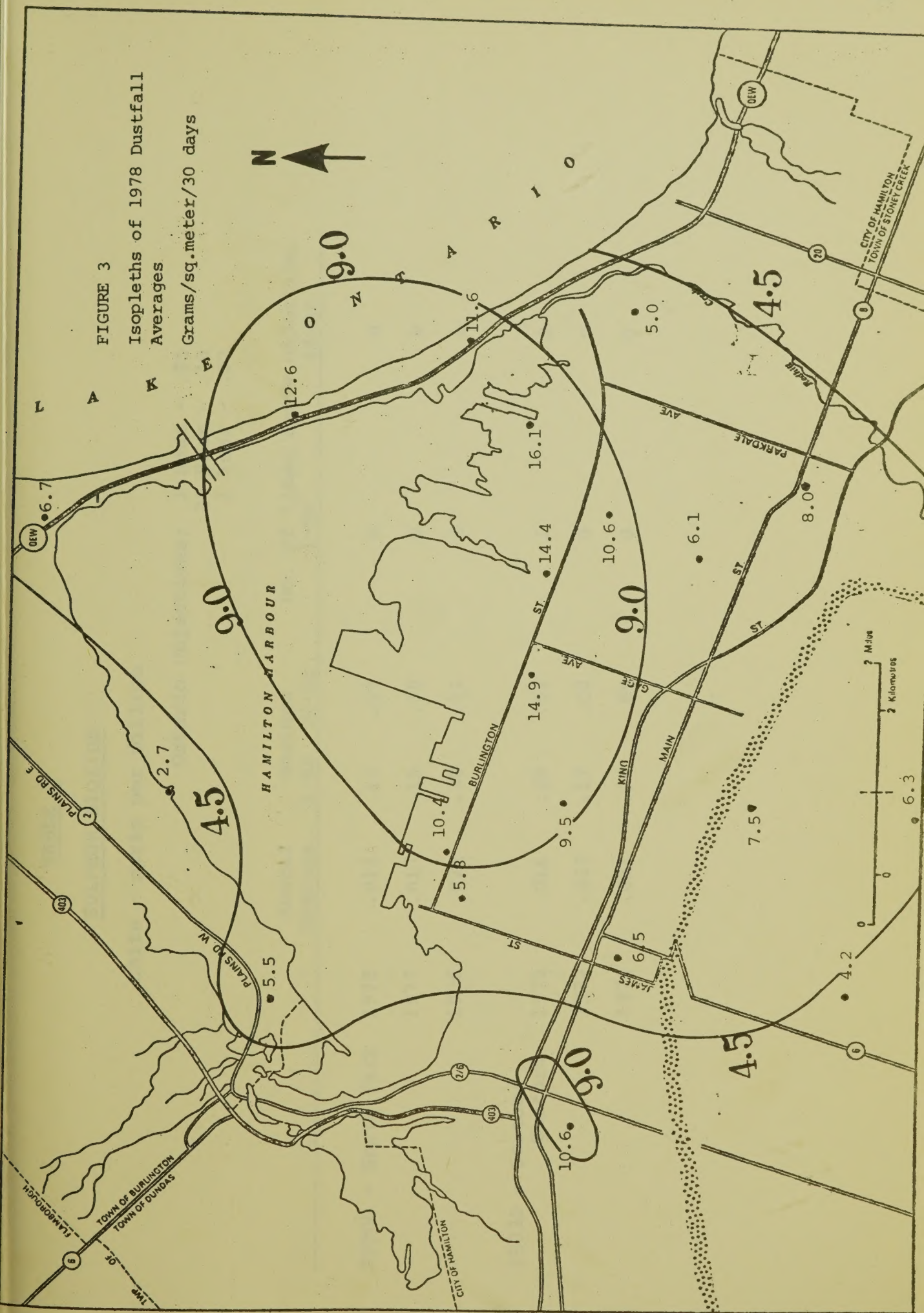


TABLE 6

SULPHUR DIOXIDE

Units - parts per million

Ontario Objectives; 1 Hour - .25
 24 Hour - .10
 1 Year - .02

		Annual Average	Maximum 1-hr	24-hr	No. of times above objective	
					1-hr	24-hr
29008 - North Park	1978	.013	.13	.07	0	0
	1977	.017	.15	.08	0	0
	1976	.021	.30	.11	2	1
29025 - Barton/ Sanford	1978	.016	.29	.07	1	0
	1977	.023	.17	.08	0	0
	1976	.021	.24	.09	0	0

TABLE 7

TOTAL REDUCED SULPHUR

Units - parts per billion

Ontario Objective: 1 Hour - 20

		Annual Average	Maximum	No. of times above objective
29008 - North Park	1978	1.2	36	5
	1977	0.8	26	2
	1976	0.8	22	1
29025 - Barton/ Sanford	1978	1.6	66	74
	1977	1.3	110	65
	1976	1.0	41	26

TABLE 8

CARBON MONOXIDE

Units - parts per million

Ontario Objective: 1-Hour - 30
8-Hour - 13

	Annual Average	Maximum		No. of times above objective	
		1-hr	8-hr	1-hr	8-hr
29025 - Barton/ Sanford	1978	1.2	9	5	0
	1977	1.4	12	7	0
	1976	1.4	14	7	0

TABLE 9

NITROGEN DIOXIDE

Units - parts per million

Ontario Objectives: 1-Hour - .20
24-Hour - .10

		Annual Average	Maximum		No. of times above objective	
			1-hr	24-hr	1-hr	24-hr
29008 - North Park	1978	.040	.14	.11	0	1
	1977	.045	.20	.14	0	3
	1976	.038	.13	.09	0	0
29025 - Barton/ Sanford	1978	.046	.18	.12	0	3
	1977	.057	.18	.13	0	2
	1976	.040	.18	.10	0	0

TABLE 10

NITRIC OXIDE

UNITS - parts per million

		Annual Average	Maximum	
			1-hr	24-hr
29008 - North Park	1978	.069	.69	.24
	1977	.073	.71	.34
	1976	.082	.89	.34
29025 - Barton/ Sanford	1978	.026	.60	.15
	1977	.030	.55	.26
	1976	.025	.81	.23

TABLE 11

NITROGEN OXIDES
(Sum of Nitrogen Dioxide and Nitric Oxide)

UNITS - parts per million

		Annual Average	Maximum	
			1-hr	24-hr
29008 - North Park	1978	.110	.76	.30
	1977	.117	.77	.40
	1976	.120	.96	.40
29025 - Barton/ Sanford	1978	.073	.64	.22
	1977	.086	.63	.36
	1976	.065	.91	.31

TABLE 12

REACTIVE HYDROCARBONS (NON-METHANE)

UNITS - parts per million

		Annual Average	Maximum	
			1-hr	24-hr
29025 - Barton/ Sanford	1978	1.72	5.4	4.0
	1977	1.89	5.4	4.2
	1976	1.61 [*]	4.7	3.6

^{*} Last five months only

TABLE 13

OZONE

Units - parts per billion

Ontario Objective: 1-Hour -80

		Annual Average	Maximum	No. of times above objective
29025 - Barton/ Sanford	1978	16.3	119	71
	1977	16.6	92	15
	1976	18.0	128	95

TABLE 14

SULPHATION RATE - 1978Units - Milligrams SO₃/100 Sq. cm/Day

Ontario Objective: 1 Month Avg. - 0.70

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1978	AVERAGE 1976	1975
29001 - Hughson/Hunter	.70	.61	.53	.52	.68	.43	.24	.38	.41	.35	.02	.89	.48	.45	.43
29006 - Queenston	.62	.74	.40	.28	.23	.29	-	.20	.23	.30	.38	.37	.37 ¹¹	.29	.32
29008 - North Park	<u>1.38</u>	<u>1.07</u>	<u>.81</u>	.33	.42	.61	<u>.95</u>	.64	<u>.71</u>	<u>1.20</u>	<u>1.21</u>	1.35	.89	.97	.86
29009 - Kenilworth	.69	<u>.94</u>	.47	.35	.38	.29	.30	.30	.37	.47	.50	.41	.46	.48	.44
29010 - Burlington/Ottawa	<u>1.60</u>	<u>1.41</u>	<u>.92</u>	<u>1.10</u>	<u>.96</u>	<u>1.01</u>	<u>.79</u>	<u>.91</u>	.33	-	-	-	1.00 ⁹	.93	.90 ¹¹
29011 - Burlington/Leeds	<u>1.23</u>	<u>.92</u>	<u>.82</u>	<u>.84</u>	<u>.92</u>	.65	.42	.61	<u>.75</u>	.64	<u>.75</u>	.43	.75	.72	.67
29012 - Burlington/Wellington	<u>.81</u>	.58	.60	.39	.50	.40	.30	.39	.59	.41	.62	.44	.50	.38	.42
29017 - Chatham/Frid	<u>.96</u>	<u>.79</u>	.55	.50	.62	.46	.20	.29	.34	.38	.50	.53	.51	.51	.49 ¹¹
29019 - Mohawk/Warren	<u>.83</u>	<u>.71</u>	.48	.50	.53	.39	.26	.37	.31	.26	.47	.39	.46	.47	.41
29025 - Barton/Sanford	<u>.92</u>	.70	.57	.69	.62	.51	.28	.40	.37	.39	.43	.40	.52	.42	.59
29026 - Woodward/Brampton	<u>.74</u>	<u>.85</u>	.52	.37	.25	.49	.36	.33	.33	.50	.49	.52	.48	.48	.43 ¹¹
29030 - Mohawk /Camden	<u>.86</u>	.68	.38	.28	.34	.31	.24	.24	.27	.39	.46	.33	.40	.36	.36
29031 - Concession/Upper Sherman	<u>.92</u>	<u>.80</u>	.54	.55	.37	.45	.30	.32	.34	.55	.55	.40	.51	.49	.50 ¹⁰

Underlined values are in excess of objective

TABLE 14 (con't)

SULPHATION RATE - 1978

Units - Milligrams SO₃/100 Sq. cm/Day

Ontario Objective: 1 Month Avg. - 0.70

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1978	AVERAGE 1976	1975
29036 - Roosevelt/Beach Rd.	<u>1.03</u>	<u>1.14</u>	.64	<u>.74</u>	.47	<u>.75</u>	.45	.41	.55	.57	.60	.51	.66	.63	.55
29037 - Strathearn	<u>1.13</u>	<u>1.18</u>	<u>.94</u>	<u>.73</u>	.45	<u>.80</u>	<u>.74</u>	<u>.55</u>	.62	<u>.80</u>	<u>.73</u>	.69	.78	.76	.75
29044 - Wark/Beach Rd.	<u>1.08</u>	<u>1.16</u>	.65	.39	.25	.41	.39	.32	.37	.48	.58	<u>.73</u>	.57	.55	.49
29046 - Highways Bldg. Burlington	.72	.58	.21	.19	.15	.18	.26	.16	-	.33	.32	.40	.32 ¹¹	.28	.28
29050 - Hopkins Crescent, Dundas	<u>.72</u>	.40	.28	.20	.22	.24	.16	.15	.18	.18	.29	.24	.27	.24	.20
29051 - Botanical Gardens	<u>1.74</u>	<u>1.11</u>	<u>.79</u>	.33	.22	.20	.10	.18	.17	.29	.29	.29	.48	.45	.36
29055 - La Salle Park, Burlington	<u>.78</u>	.63	.41	.20	.27	.25	<u>.89</u>	.24	.16	.39	.38	.34	.41	.33	.37 ⁶
29060 - Stoney Creek Munic. Office	.66	.68	.38	.15	.13	-	.20	.21	.37	.37	.30	.48	.36 ¹¹	.38	.33
29067 - 450 Hughson North	.43	.49	.41	.25	.26	-	-	.16	.31	.37	.43	.41	.35 ¹⁰	.34	.30

Underlined values are in excess of objective

TABLE 15

FLUORIDATION RATE - 1978

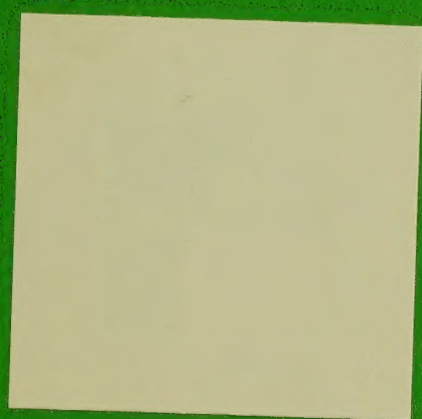
Units - Micrograms /100 sq. cm/30 Days

Ontario Objective: Apr. 15 to Oct. 15 - 40
Oct. 16 to Apr. 14 - 80

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	1978	AVERAGE 1977	1976
29001 - Hughson/Hunter	54	29	38	57	87	39	24	42	52	21	22	24	41	37	29
29008 - North Park	<u>164</u>	<u>135</u>	<u>98</u>	49	<u>62</u>	<u>81</u>	<u>63</u>	<u>64</u>	<u>43</u>	<u>127</u>	-	<u>393</u>	<u>116</u> ¹¹	98	133
29012 - Burlington/Wellington	47	32	45	34	<u>65</u>	<u>42</u>	33	28	<u>55</u>	34	57	39	43	<u>33</u> ¹¹	30
29017 - Chatham/Frid	50	39	47	59	<u>105</u>	<u>54</u>	<u>43</u>	40	<u>62</u>	33	42	36	51	41	39
29025 - Barton/Sanford	76	46	43	<u>67</u>	<u>99</u>	<u>52</u>	<u>41</u>	<u>52</u>	<u>57</u>	31	34	25	52	48	45
29026 - Woodward/Brampton	59	77	50	51	<u>63</u>	<u>56</u>	<u>46</u>	<u>42</u>	37	56	36	64	53	48	63
29054 - Conrad/Beach Rd.	56	<u>93</u>	52	<u>92</u>	<u>65</u>	<u>119</u>	<u>64</u>	<u>54</u>	<u>57</u>	<u>83</u>	54	53	70	69	65
29058 - Q.E.W./Skyway	<u>172</u>	<u>276</u>	<u>183</u>	<u>141</u>	<u>85</u>	<u>132</u>	<u>143</u>	<u>120</u>	<u>120</u>	<u>171</u>	<u>162</u>	<u>334</u>	170	135	150
29059 - Burlington/Gage	<u>190</u>	<u>241</u>	<u>86</u>	<u>110</u>	-	-	<u>127</u>	<u>103</u>	<u>126</u>	<u>133</u>	<u>134</u>	<u>123</u>	<u>137</u> ¹⁰	84	<u>76</u> ¹¹
29062 - Briarwood School, King St. E.	67	73	<u>84</u>	<u>79</u>	<u>73</u>	<u>81</u>	<u>52</u>	<u>41</u>	38	70	80	<u>82</u>	68	<u>63</u> ¹¹	<u>48</u> ¹¹
29066 - Killarney/Beach Blvd.	<u>150</u>	<u>144</u>	-	<u>132</u>	<u>74</u>	<u>58</u>	<u>59</u>	<u>62</u>	<u>51</u>	<u>104</u>	<u>104</u>	<u>272</u>	<u>110</u> ¹¹	81	80

Underlined values are in excess of objective.

For April and October, objective is considered to be 60



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